भारतीय मानक

Indian Standard

IS 11315 (Part 12) : 2023

रॉक मास में दरारों के मात्रात्मक विवरण के तरीके

भाग 12 ड्रिल कोर स्टडी

(पहला पुनरीक्षण)

Methods for Quantitative Description of Discontinuities in Rock Masses

Part 12 Drill Core Study

(First Revision)

ICS 93.060

भारतीय मानक ब्यूरो
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August 2023 **Price Group 7**

Rock Mechanics Sectional Committee, CED 48

FOREWORD

This Indian Standard (Part 12) (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Rock Mechanics Sectional Committee had been approved by the Civil Engineering Division Council.

A series of Indian Standard on test methods for assessing the strength characteristics of rocks and rock masses are being developed/revised in view of recent advances in the field of rock mechanics. The majority of rock masses, in particular, those within a few hundred metres from the surface, behave as discontinuous, with the discontinuities largely determining the mechanical behaviour. It is, therefore, essential that structure of a rock mass and the nature of its discontinuities are carefully described and quantified to have a complete and unified descriptions of rock masses and discontinuities. Careful field descriptions will enhance the value of in-situ tests that are performed since the interpretation and extrapolation of results will be made more reliable.

Discontinuity is the general term for any mechanical discontinuity in a rock mass, along which the rock mass has zero or low tensile strength. It is the collective term for most types of joints, weak bedding planes, weak schistosity planes, weakness zones, shear zones and faults. The ten parameters selected for rock mass survey to describe discontinuities are orientation, spacing, persistence, roughness, wall strength, aperture, filling, seepage, number of sets and block size. These parameters are also evaluated from the study of drill cores to obtain information on the discontinuities.

It is essential that both the structures of a rock mass and the nature of its discontinuities are carefully described for determining the mechanical behaviour. This Indian Standard, covering various parameters to describe discontinuities in rock masses.

This standard (Part 12) covers the methods for quantitative description of discontinuities in rock masses for drill core study. This standard (Part 12) was first formulated in 1992. This revision incorporates the latest advancement and modifications based on the experience gained in the use of this standard. The other parts formulated in the series are:

Part 1	Orientation
Part 2	Spacing
Part 3	Persistence
Part 4	Roughness
Part 5	Wall strength
Part 6	Aperture
Part 7	Filling
Part 8	Seepage
Part 9	Number of sets
Part 10	Block size
Part 11	Core recovery and rock quality designation

This standard is based on suggested method of International Society for Rock Mechanics. Following standards on core drilling and core study have also been published by the BIS:

IS 4464 : 2020 Code of practice for presentation of drilling information and core description in geotechnical investigation (*second revision*)

IS 5313 : 2020 Guide for core drilling observations (*second revision*)

The composition of the Committee responsible for the formulation of this standard is given in Annex A.

(*Continued on third cover*)

Indian Standard

METHODS FOR QUANTITATIVE DESCRIPTION OF DISCONTINUITIES IN ROCK MASSES

PART 12 DRILL CORE STUDY

(First Revision)

1 SCOPE

The standard (Part 12) covers the method of quantitative description of discontinuities from drill core study.

2 REFERENCES

The standards given below contain provisions which through reference in this text, constitute provision of this standard. At the time of publication, the editions indicated were valid. Any standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent edition of these standards:

IS No.	*Title*
IS 1269	Legal metrology — Material measures of length:
(Part 1) : 1997	Woven metallic and glass fiber tape measures (*second revision*)
(Part 2) : 1997	Steel tape measures
IS 5529	Code of practice for *in-situ* permeability test:
(Part 1) : 2013	Test in overburden (*second revision*)
(Part 2) : 2006	Test in bedrock (*second revision*)
IS 11315	Method for the quantitative description of discontinuities in rock mass:
(Part 4) : 2023	Roughness
(Part 5) : 2023	Wall strength
(Part 10) : 2023	Block size
(Part 11) : 2023	Core recovery and rock quality designation
IS 11358 : 1987	Glossary of terms and symbols relating to rock mechanics

3 TERMINOLOGY

For the purpose of this standard, the definition of terms given in IS 11358 shall apply.

4 GENERAL

4.1 Very high (nearly 100 percent) core recovery is necessary for accurate quantitative assessment of the discontinuity in a rock mass. This fact is illustrated by Fig. 1, Fig. 2 and Fig. 3 showing nearly 100 percent core recovery in all the three drill holes. Suppose there is no core recovery for the zone 'X' (extremely broken cores) and 'Y' (shattered cores) in Fig. 2 and Fig. 3 respectively and if quantitative measurements are done only on the remaining portions of cores (with few discontinuities), it will show a different picture. Even if the zone marked 'F' in Fig. 1, is not recovered during drilling the main defect of the rock will remain unassessed.

4.2 For quantitative descriptions of the discontinuities NX diameter (54 mm) or NQ diameter (48 mm) size cores shall be used. Recovery of high percentage of cores, irrespective of the nature of rock (hard, soft or highly fractured) depends on the techniques of drilling, applied pressure and the efficiency level of the drilling personnel. Generally good core recovery may be assured by adopting correct drilling techniques and special coring equipment. In this connection, the use of double or triple tube core barrel with bottom discharge bits would be found useful in ensuring the maximum possible core recovery in soft rock or fractured hard rock. Special drilling techniques in such cases may call for short runs of drilling and judicious control of water supply and speed of drilling. Core recovery may be ruined by drilling too fast, over drilling a run, or dropping core and grinding it, or not pulling out the tools when the barrel is jammed and thereby grinding the core. This also damages the bit. Vibration in the drill string causes poor core recovery, diamond losses in bits and shells, wear and tear on drills and loss of footage.

4.3 Colour photographs provide a useful and convenient method of recording, the appearance of cores and are of considerable value as a permanent record land means of rapid reference. The photograph of each core box should incorporate a suitable metric scale along with the entire length of the box.

4.4 The drill core can first be described by means of the following parameters: total appearance core recovery (R), discontinuity frequency (F), and rock quality designation (RQD). However, these parameters alone do not usually provide sufficient information for design purposes.

4.5 Drill cores (and drill holes) represent line samples of the rock mass. Structural features such as discontinuity orientation, spacing and the number of sets cannot normally be adequately studied from one hole.

4.6 Carefully planned and executed core drilling followed by detailed core description and hole inspection can provide approximate information about many of the ten specific rock mass parameters.

4.7 Attitudes of the discontinuities may be measured in quantitative terms with reference to the long axis of the drill core. In case the drill hole is inclined, some corrections are necessary in the measured values depending upon the inclination of the drill holes or prior knowledge of the attitudes of the discontinuity from rock outcrops.

4.8 Measuring tape of at least 3 m length calibrated in mm divisions and protractor, or similar scale equipment shall be used for measuring lengths and angles between the core axis and the discontinuities. The detail of measuring tape is given in IS 1269 (Part 1 and 2).

4.9 Measurements in drill holes for collecting information on the discontinuities from drill core information, require the use of borehole periscope camera or TV camera or borehole imagery by acoustic methods. Water level measurements and water percolation tests conducted at regular intervals in the drill hole also provide proper information of the nature and intensity of discontinuity at depths.

5 PROCEDURE

5.1 At the beginning, the major geological features like the rock types, lithological boundaries and the geological structures should be examined. The details of the discontinuity in each run and in each rock type may then be carefully recorded. The nature of the discontinuity should also be identified.

5.2 Total core recovery (R) defined as the summed length of all pieces of recovered core expressed as a percentage of length drilled should be accurately measured. When the core is highly fragmented the length of such portions is estimated by assembling the fragments and estimating the length of core that the fragments appear to represent [*see* IS 11315 (Part 11)].

The cores in the box should be kept with proper care so that it represents the actual order of recording with reference to depths. Cores of each run should be kept separately using wooden blocks. The drill cores thus arranged in the core boxes should not be disturbed during transportation or by rough handling.

5.3 Frequency (F) defined as the number of natural discontinuities intersecting a unit length of recovered core, should be counted for each metre of core. The procedure given in **5.4.1.1** may be followed to differentiate natural discontinuity from artificial one.

5.4 Rock quality designation (RQD) is a modified core recovery percentage in which all the pieces of sound core over 10 cm long are counted as recovery, and are expressed as a percentage of the length drilled. The smaller pieces resulting from closer jointing, faulting or weathering are discounted [*see* IS 11315 (Part 11)].

5.4.1 RQD values should be determined for variable rather than fixed lengths of core run. Values of individual beds, structural domains, weakness zones, etc, should therefore be logged separately, so as to indicate any inherent variability, and provide a more accurate picture of the location and width of zones with low or zero RQD values.

5.4.1.1 When estimating frequency or RQD from drill core it is necessary to discount artificial or mechanical breaks (fractures) caused by the drilling process, or handling when fitting core into the core boxes. The following criteria are suggested:

a) A rough brittle surface with fresh cleavage planes in individual rock/minerals indicates an artificial fracture;
b) A generally smooth or somewhat weathered surface with soft coating or infilling materials such as talc, gypsum, chlorite, mica or calcite obviously indicates a natural discontinuity;
c) In rocks showing well developed foliation, schistosity, cleavage or thin bedding, the cores may split easily during drilling or by wrong handling. It may be difficult to distinguish between natural discontinuities

and artificial fractures. It is suggested that the questionable breaks should be counted as natural features, to be on the conservative side;

d) Depending upon the drilling equipment and nature of rock formation part of the length of core being drilled may occasionally rotate with the inner barrels in such a way that grinding of the surfaces of discontinuities and fractures occurs. In weak rock types it may be very difficult to decide if the result in grounded surface represent natural or artificial features. When in doubt the conservative assumption should be made to assume that they are natural; and

e) It may be useful to keep a separate record of the frequency of artificial fractures (and associated lower RQD) for assessing the possible influence or blasting on the weaker sedimentary and foliated or schistose metamorphic rocks.

5.4.1.2 The degree of fracturing of the core during the drilling process may be partly a function of core diameter in the weaker rock types. As suggested in **4.2**, NX diameter (54 mm) or NQ diameter (48 mm) cores should be drilled to minimise fracturing. Smaller diameter like BX (41 mm) or AX (29 mm) causes more fractures and more core loss.

5.4.1.3 The different types of measurements for core lengths have been illustrated in Fig. 4. A tip to tip measurement, 'X' may give double counting. The measure 'Y' which includes the total length of the full surface core 'Z' and half of the split portion may be adopted so that the total core recovery for all the pieces together is equal to the total recovery of the run. Then length, 'Z' alone may be considered for a conservative estimate.

5.4.1.4 The results of core logging (frequency and RQD), can be time dependent and moisture content dependent in the case of certain varieties of shales and mudstones having relatively weakly developed diagenetic bonds and containing sulphide minerals. A frequent problem is 'discing' in which an initially intact core separates into discs on incipient places after exposure to nature. The phenomena are experienced in several different forms as follows:

a) Stress relief cracking (and swelling) by the initially rapid release of strain energy in cores recovered from areas of high stress, especially in the case of shally rocks;

b) Dehydration cracking experienced in the weaker mudstones and shales under atmospheric condition, may reduce RQD from 100 percent to 0 percent; and

c) Slaking cracking experienced by some of the weaker mudstones and shales when subjected to wetting.

5.4.1.5 The phenomena described in **5.4.1.4** make core logging of frequency and RQD unreliable. Whenever such conditions are anticipated core should be logged by an engineering geologist. An added advantage is that the engineering geologist can perform mechanical index tests such as the point load or Schmidt hammer test, while the core is still in a saturated state.

5.5 Subsequent to the general procedure for logging total core recovery (R), frequency (F), and rock quality designation (RQD), the following supplementary procedures are suggested for determining as much quantitative data as possible concerning the following ten parameters:

a) Orientation;
b) Spacing;
c) Persistence;
d) Roughness;
e) Wall strength;
f) Aperture;
g) Filling;
h) Seepage;
j) Number of sets; and
k) Block size.

5.6 Out of the above parameters mentioned in **5.5**, spacing, roughness, wall strength and number of sets are measurable from the drill cores. The filling may be examined if the filled materials are recovered by the hole or if the recovery of the drill cores is cent percent as illustrated in Fig. 1 and Fig. 3. The other parameters like orientation, persistence, aperture, seepage and block size are best studied from the rock outcrops or in drift, adit or tunnel rocks; but use of borehole periscope, borehole camera or TV camera or bore hole imagery by acoustic methods and water injection tests help measurement of these parameters in drill cores or in drill holes.

5.7 There is distinct relation of seepage/permeability with apertures. It is suggested to study results of water percolation tests in consideration of the core recovery percentage, RQD, spacing and frequency of discontinuities. This will help to understand the openness of the apertures, seepage, intensity and persistence of the discontinuity at depth in the drill holes. This fact has been illustrated in Fig. 5. In general low RQD indicates high fracture frequency or close spacing of discontinuities and if high order seepage/permeability is observed at same depth in the water injection test, it is indicative of open nature of fracture apertures (*see* Fig. 5).

6 ORIENTATION

6.1 Effort should be made to log the apparent orientation of discontinuities intersecting the core, using a protractor to measure the acute angles of intersections (θ) relative to core axis (0 ± 5°). If the relevant hole is vertical the angles (90° – θ) will represent the true dip of the discontinuities, but without orientated core the dip direction will remain unknown.

6.2 If two or more non-parallel drill holes have been drilled in a rock mass where there are recognisable markers such as bedding or foliation, the dip direction and dip of these features can be deduced using graphical techniques. But it may not be possible to measure true dips of all the fractures by this technique.

6.3 If existing surface mapping has already indicated the approximate orientation of certain joint sets, then carefully orientated drill holes can be used to check the orientation of these features at depth. In the case of anticipated vertical and horizontal jointing it is helpful to drill steeply inclined holes (that is, 60°) in preference to 45°, so that the differently orientated sets can be recognised during core logging by their different core intersection angles

6.4 The true orientation of discontinuities (dip direction and dip) may be obtained from a single drill core if orientation devices are employed during the drilling process, several methods are available:

a) Orientation of the core based on the measured orientation in each run (Craclius method). This method works well if adjacent pieces of core can be matched. Zones of core loss and perpendicularly intersected discontinuities reduce the effectiveness of the method locally;
b) Orientation of the core by means of a hardened steel groove scriber and compass photo device; and
c) Integral sampling method in which the cores that are recovered have previously been reinforced with a grouted bar whose azimuth is known from positioning rods. The reinforcing bar is co-axially covered with a larger diameter coring crown.

6.5 The orientation of discontinuities (dip direction and dip) may be obtained by drill hole inspection using special television cameras and periscopes, TV cameras may be oriented such that a discontinuity plane shows as a straight line on the CRT screen. The dip direction and dip may be readily determined. Cameras may be used to depths of 400 m, though generally 150 m is seldom exceeded due to water pressure problems. Minimum hole size for the cameras is generally 76 mm.

6.6 The borehole periscope may be used in smaller holes, but due to distortion of the optical path the depth is usually limited to about 30 m.

6.7 Borehole Televiewer (BHTV) may be used for borehole imagery either be acoustic borehole imaging (ABI) or optical borehole imaging (OBI) to get true dip amount and dip direction. Correction for inclination of boreholes could be done during processing of borehole images. OBI could not be used if water filled in the borehole obstructs clear visibility.

7 SPACING

7.1 In rock with marked foliation or bedding features it should be possible to match the individual core pieces such that the actual spacing of obliquely intersected foliation joints, bedding joints or other regular intersecting joint sets may be estimated. The spacing (S) will depend on the length (L) measured along the core axis between adjacent natural discontinuities of one set, and the acute angle (θ) that these features subtend with the core axis. Thus:

$$S = L \sin \theta$$

7.2 The angles (θ) between the core axis and the individual joints of a given set will be inherently less reliable than these recorded from observations of rock exposures due to the possibility of joint undulation and roughness.

7.3 When a joint set is intersected perpendicularly by the drill hole, spacing can obviously be measured directly since (S) is equal to (L). Thus a vertical drill hole will measure accurately the spacings of horizontal discontinuities.

7.4 When the rock has no consistent or clear marker features, such as foliation or bedding, the estimation of spacing for any given set of joints will depend on the degree to which the core pieces can be matched. Zones of core loss will clearly frustrate this objective. However, if the joints that intersect the core have markedly different core intersection angles (θ) and/or markedly different surface features (that is, mineral coatings, roughness) it may be possible to estimate the relevant spacings in a sufficient number of places along the core to make the exercise worthwhile.

7.5 Borehole viewing devices that may be oriented (periscope, TV camera) shall clearly increase the reliability of spacing measurement.

8 PERSISTENCE

Unless holes are drilled in a very closely space pattern, as may be the case for operations such as grout curtain injection, it shall usually not be possible to access the persistence from drill core or drill hole observations. If closely spaced holes are available, very careful correlation of discontinuities shall be required before any reliable conclusions is drawn concerning the persistence of a given discontinuity or set. But persistence of certain major discontinuities like fault or shear zones or a contact of two rock units may be traced from the cores of several drill holes of the same locality.

9 ROUGHNESS

9.1 Gross features of discontinuity wall roughness and corresponding full scale shear strength may not obviously be assessed by means of drill core along. However, it is usually possible to assign to a surface some degree of planarity (planer, curved, irregular) and suggested procedure is broadly consistent with the roughness description in IS 11315 (Part 4).

9.2 Roughness in core piece may be well studied from the surface of the natural fractures by visual observations or by profile gauge and comparison with the standard chart (for example, Barton's chart) to measure the roughness by fixed number.

9.3 Drill hole inspection with periscope or TV cameras shall not generally provide an improved picture of roughness unless the rock type is so weak and/or the drilling so poorly performed that grinding of the core pieces has occurred.

10 WALL STRENGTH

10.1 The individual methods for describing wall strength like weathering grade of rock mass, weathering grade of rock material, manual index tests and Schmidt hammer test in accordance with IS 11315 (Part 5) may also be applied to the description of drill core.

10.2 Since the drill core provides a readymade line samples of rock mass, such features as the depth of penetration of weathering into the discontinuity walls can be directly observed and therefore described quite accurately. Furthermore, the drill core provides readymade samples for mechanical testing (that is, Schmidt hammer testing of rigidly clamped core pieces for describing wall strength or point load testing across the core diameter for describing material strength). Logging the point load strength index (I_s) simultaneously with recovery of the core from the core barrels provide reliable estimates of *in-situ* strength.

10.3 When assessing wall strength, care should be taken to check if the relevant core pieces fit together. Lack of fit may indicate lost filling material, shear displacement, or partial grinding away of strongly weathered walls during the drilling process.

11 APERTURE

11.1 The aperture of discontinuities is not preserved in rock cores and as such this parameter is not possible to measure unless undisturbed samples are available which will require special sampling techniques.

11.2 Drill hole inspection using BHTV should be successful in distinguishing between the above tight and open categories, although it is unlikely that the apertures of the finest joints can be measured accurately. From the point of view of seepage potential, the open discontinuities are most important, so this limitation should be important where highly permeable rock masses are concerned. Methods are available for estimating the theoretical smooth wall apertures of water conducting discontinuities by statistical analysis of water injection tests. However, the real apertures may be several times the theoretical smooth wall apertures due to wall roughness and tortuosity effects.

11.3 The most important factor for design purposes is the nature of aperture with respect to its openness. The water injection test results if considered with other factors like RQD and fracture frequency (as discussed in **5.7** and illustrated in Fig. 5) may be used to assess whether tight.

12 FILLING

12.1 Unless the integral quality drilling equipment sampling method or best is used (that is, double or triple tube core barrels, split inner tubes, and controlled flushing the softer filling materials are unlikely to be recovered in significant amounts. Possibly only traces of clay minerals shall be visible on the discontinuity walls sampled by conventional drill core. Both traces and larger amount of recovered filling should be described as to width, minerology and strength. The interpretative nature of these descriptions should be made clear.

12.2 Where total core recovery is less than 100 percent and is suspected that significant amounts of filling or weathered material has been lost in the drilling process attempts should be made to assess the thickness, location and orientation of the suspected filled zones. The drillers log describing the rate of advance and water loss, type of cutting and colour of flushing fluid may be invaluable here.

12.3 The uncertainties surrounding the parameter filling and its extreme importance where deformation, stability and water seepage are concerned, strongly justify the use of special recovery techniques and the use of borehole viewing techniques.

13 SEEPAGE

13.1 Observations of drill core may provide indirect evidence of water seepage levels. Reddish-brown iron (Fe^{3+}) staining usually indicates the zone of rock mass that lies above the mean ground water level. Oxidation in discontinuity walls lying beneath the ground water level may also occur, but at a greatly reduced rate. Frequently the strongest iron staining is found in the zone where the ground water level commonly fluctuates.

13.2 Drill holes obviously provide the means of checking ground water levels directly using simple battery operated electrical contact devices which are lowered into the holes. Additional information on standing water levels should be obtained from the drillers log for each drill hole. Drill hole walls may be surveyed for seepage horizons using BHTV.

13.3 Testing performed in drill holes that is falling head test [*see* IS 5529 (Part 1)], Lugeon Packer tests [*see* IS 5529 (Part 2)] tracer tests, piezometer measurements for estimating rock mass permeability, and for estimating the hydraulic conductivity of individual discontinuities also provide estimate of seepage along set of discontinuities. The logging and presentation of any available Lugeon values give important supplementary data, which may be presented as a log, parallel with that for total core recovery frequency and RQD, etc (*see* Fig. 5).

13.4 Thermal borehole flowmetry tests can be used to measure the rate and the direction of water flow (from the rock mass towards the borehole or reverse) in the tested boreholes, this allows to identify water bearing fractures crossed by the considered holes as well as the flow pattern along the borehole. This allows for a first approximation of the hydraulic conductivity profile along the borehole as well as a preliminary quantification of the hydraulic gradients within the borehole. Thermal borehole flowmetry is generally used to measure very small flow rates and to identify hydraulic active fractures along a borehole. The type of flowmeter test consists in applying the heat pulse method to determine temperatures along the entire length by applying an artificial heat pulse. This test is always coupled to a caliper log, borehole imagery and electrical conductivity logging.

14 NUMBER OF SETS

14.1 The amount of information obtainable from drill core and drill hole observation will obviously depend on the orientation of the holes relative to the joint spacing. If existing surfaces mapping has already indicated the approximate orientation of certain discontinuity sets, then carefully oriented holes may be used to check the number of sets at depth. Drill core observation shall be easier if holes are drilled to intersect the different sets at recognisably different angles. Usually at least two non-parallel holes shall be required.

14.2 The number of sets observed at the surface is likely to be more than the number observed at depth. Comparison of surface observations with tunnel excavations suggests that this is not just due to the limitations of drill hole sampling.

15 BLOCK SIZE

The term block size is a composite description of rock mass which is influenced by spacing, number of sets, persistence and orientation. A log of block size produced from observations of rock core may clearly only give an approximate picture of the true block size from drill core. It is desirable to select by eye several typical pieces of core and take their average dimensions (± 10 percent). Each rock unit or domain may be assessed in this way. If the relevant hole is orientated such that all sets present are intersected (that is, a diagonal hole in the case of a cubic joint system) then these average core pieces shall roughly represent the block size index (I_b) as defined in IS 11315 (Part 10). A depth log showing the variation of this index may be very useful supplement to drill core description.

16 PRESENTATION OF RESULTS

16.1 Core log format should be based on the specific requirements of the rock engineering project for which the core study is being done. Following should be used as check list, so that relevant information is included, but irrelevant data excluded.

16.2 The following information should generally be furnished. This information may be written at the top of the log sheet/chart:

a) Name of the project;
b) Drill hole No.;
c) Degree of inclination of the hole with direction in case of inclined hole;
d) Collar elevation;
e) Size of the core, NX, BX or AX, NQ etc;
f) Type of drilling machine and accessories used; and
g) Dates of starting and completion of the hole with total depth drilled.

16.3 The log sheet/chart or diagrammatic representation data should the following parameters (*see* the illustration in Fig. 5)

a) Rock type by symbols with traces of bedding/ foliation/ discontinuities representing approximate dip;
b) Depths of each run of drill hole;
c) Core recovery percentage of each run/or core recovery of particular rock type;
d) Frequency (F) or number of sets;
e) Rock quality designations (RQD); and
f) Results of water injection test (preferably in Lugeon values).

16.4 The other important data including the strength parameter which should be presented specially to satisfy the specific design requirements are as follows:

a) Point load or Schmidt hammer tests for strength index;
b) Block size index (I_b);
c) Roughness number (comparing standard chart);
d) Degree of weathering or slake-durability test in case of soft rock, for example, shale, mudstone; and
e) Filling material including clay minerals.

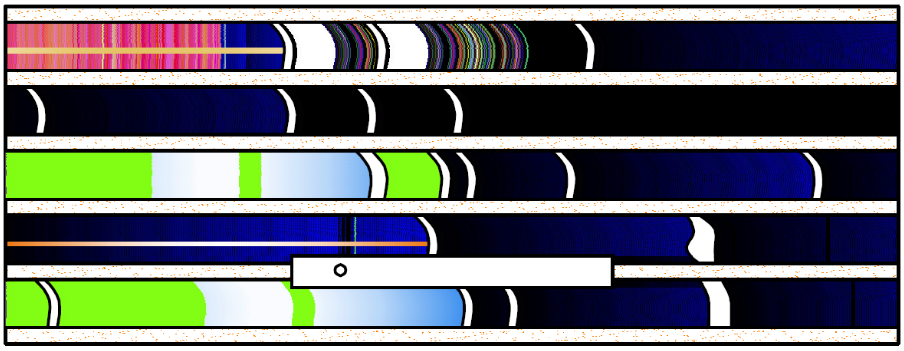
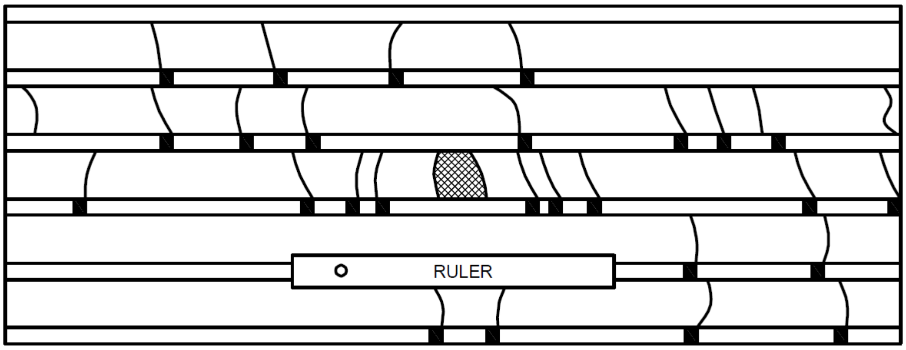


FIG. 1 2.5 cm WIDE CRUSHED ZONE (F) WITH CALCITE AND MONTMORILLONITE EXCEPT THIS DISCONTINUITY (MAJOR DEFECT IN ROCK MASS) THE CORES OF THE REMAINING PORTIONS SHOW HIGH RQD AND LOW FREQUENCY OF DISCONTINUITIES



F = Fault zone/shear zone
N = Natural discontinuity
A = Artificial discontinuity

SKETCH OF FIG. 1

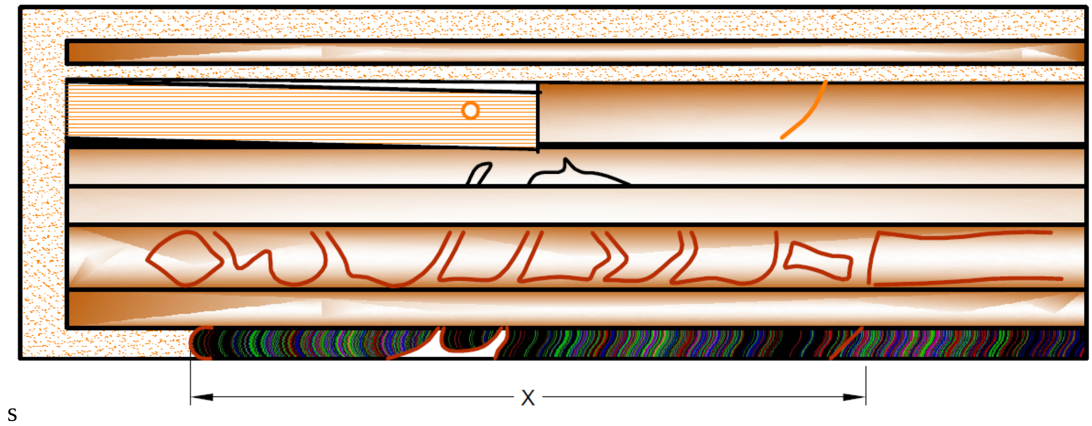


FIG. 2 INTENSELY FRACTURED ROCK IN THE PORTION MARKED 'X' (4TH LINE). THERE IS ANOTHER ZONE OF FRACTURING IN 3RD LINE. BECAUSE OF THE FRACTURING THE OVERALL. RQD ID LOW AND FREQUENCY OR DISCONTINUITIES VERY HIGH

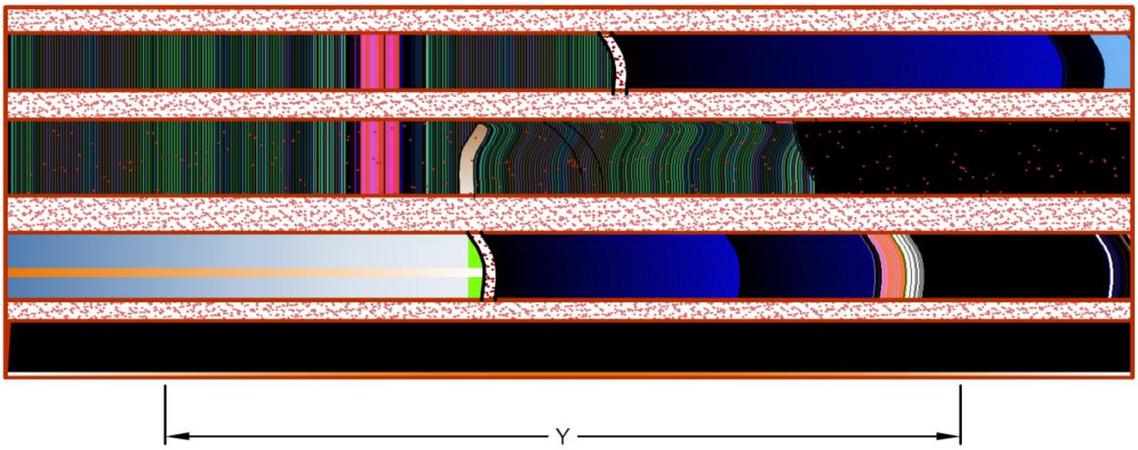
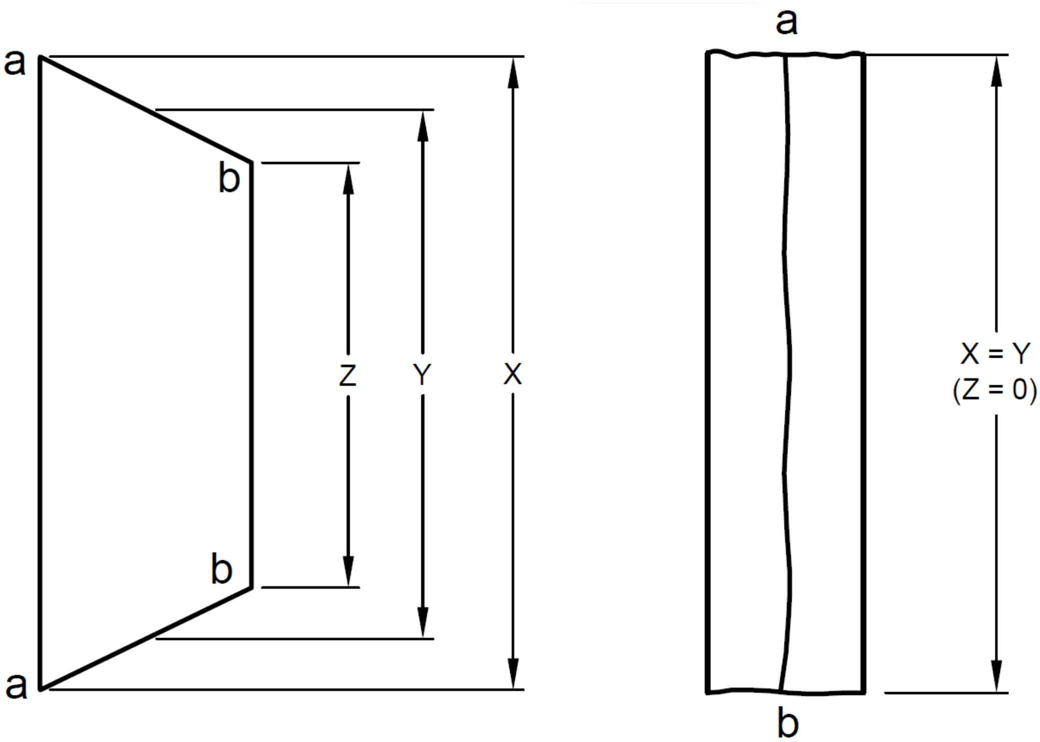


FIG. 3 INTENSITY CRUSHED ROCK WITH CLAY FILLING OR CLAY GOUGE IN THE PORTION MARKED 'Y' (4TH LINE) THE CORES IN THE REMAINING PORTIONS SHOW COMPETENT ROCKS WITH FEW DISCONTINUITIES



X = Tip to tip length
Z = Full surface core length
Y = Total length of full surface and half of split parts of core

FIG. 4 MEASUREMENT OF CORE LENGTH (A – B DISCONTINUITY)

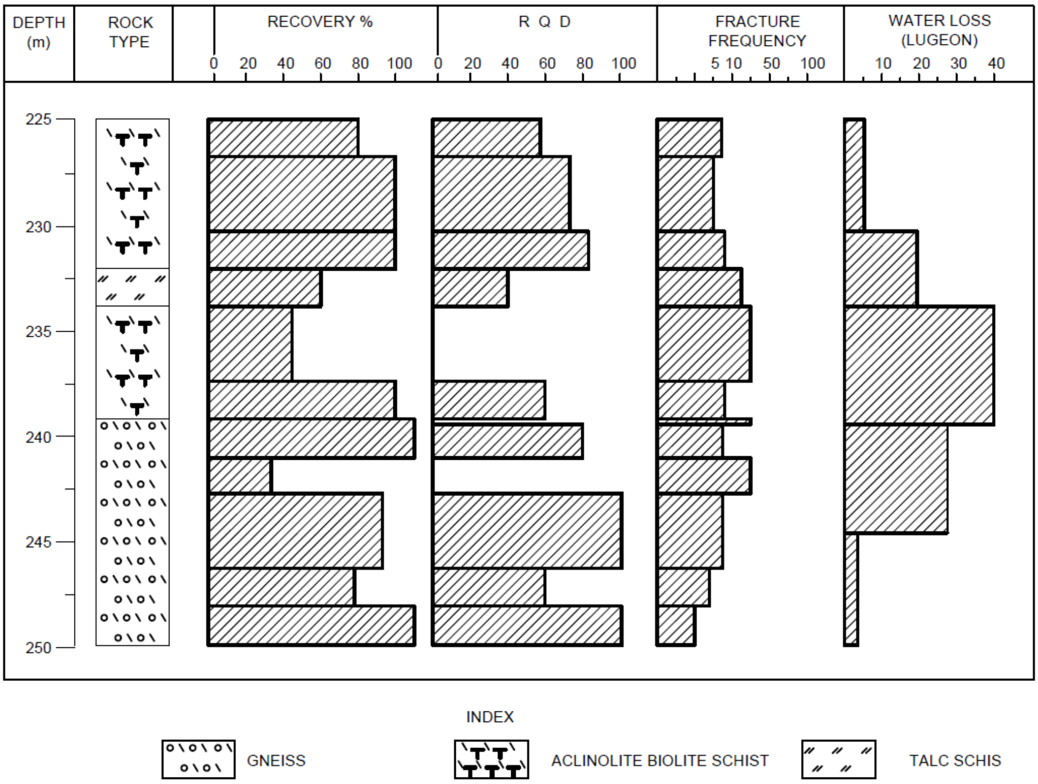


FIG. 5 DIAGRAMMATIC REPRESENTATION OF ROCK TYPE WITH TRACE OF FOLIATION DIP, CORE RECOVERY, RQD, FRACTURE FREQUENCY AND WATER TRANSMITTABILITY IN LUGEONS THROUGH THE FRACTURES/DISCONTINUITIES IN ROCK OF THE DRILL HOLE AT DIFFERENT DEPTH

ANNEX A

(*Foreword*)

COMMITTEE COMPOSITION

Rock Mechanics Sectional Committee, CED 48

Organization	*Representative(s)*
Indian Institute of Technology Roorkee	DR N. K SAMADHIYA (***Chairperson***)
AIMIL Ltd, New Delhi	SHRI AKHIL RAJ
Amberg Technologies, Gurugram	SHRI KRIPAL CHOUDHARY SHRI RAKESH PANDITA (*Alternate*)
Border Roads Organisation, New Delhi	LT COL ANIL RAJ
Central Board of Irrigation & Power, New Delhi	SHRI G. P. PATEL SHRI UDAY CHANDER (*Alternate*)
Central Soil & Materials Research Station, New Delhi	SHRI HARI DEV SHRI MAHABIR DIXIT (*Alternate*)
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This Indian Standard has been developed from Doc No.: CED 48 (19675).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

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Published by BIS, New Delhi